THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Cadmium and Cadmium Compounds

This fact sheet is part of a series of chemical fact sheets developed by TURI to help Massachusetts companies, community organizations and residents understand the chemical's use and health and environmental effects, as well as the availability of safer alternatives. Since companies report usage under the Toxics Use Reduction Act, readers will learn how the chemicals are being used and by which companies.

Cadmium (Cd) is a soft, silver-white, low-melting-point metal. Cadmium is extracted mainly as a byproduct of the mining and processing of zinc, lead, or copper. Cadmium has many uses in industry and consumer products, mainly in batteries, pigments, coatings and plating solutions, polymer stabilizers, metal alloys, and some other compounds.

Due to its serious adverse effects on human health and the environment, Cd is subject to multiple regulations at the state, federal, and international levels.

Cadmium and cadmium compounds were designated as higher hazard substances under the Toxics Use Reduction Act in January 2008, which reduces the associated reporting thresholds to 1,000 lbs/year.

Health and Environmental Impacts

Human health and environmental impacts may result when exposure to Cd and Cd compounds occurs. The following is a brief summary of potential exposure routes and the associated human health and environmental impacts.

Exposure Routes

For the general population, the major route of exposure to Cd is ingestion of food. Smoking is another major source of Cd intake. Ingestion of drinking water and inhalation of Cd aerosols from the atmosphere are also potential sources of Cd exposure.

The primary route of occupational exposure is inhalation of dust and fumes. Accidental ingestion of dust from contaminated hands, cigarettes, or food can also occur. Occupational exposure occurs primarily in smelting and refining zinc, lead, and copper ores; welding or remelting of Cd-coated steel; working with solders that contain Cd; producing, processing, and handling Cd powders; spraying Cd containing pigments; and processing scrap metal containing Cd.

CADMIUM FACTS	
Chemical Formula	Cd
CAS Number	7440-43-9
Vapor Pressure	1 mm Hg at 394°C
Water Solubility	Cd is insoluble; Cadmium compounds' solubility varies from insoluble to soluble
Description	Soft, silver-white metal

Human Health Effects

Acute (Short-term) Health Effects

- Cadmium is irritating to the nose and throat.
- Inhalation of very high levels of Cd can severely damage the lungs and may cause death.
- Ingestion of very high levels of Cd severely irritates the stomach, leading to vomiting, diarrhea, and sometimes death.

Chronic (Long-Term) Health Effects

Cadmium is carcinogenic to humans. The International Agency for Research on Cancer (IARC) classifies Cd and Cd compounds as Group 1 carcinogens (carcinogenic to humans). The U.S. EPA classifies Cd as a Group B1 (probable human) carcinogen by inhalation. NIOSH considers Cd (and Cd compounds) dust and Cd (and Cd compound) fumes to be potential occupational carcinogens.

Recent studies link exposure to Cd to bladder cancer and chronic obstructive airway disease (COAD)

Breathing airborne particles containing Cd over long periods of time may cause lung damage and fragile bones.

Breathing air with lower levels of Cd for long periods of time results in a build-up of Cd in the kidneys, which may result in kidney impairment.

Human and animal studies have reported limited evidence of an increase in risk of lung cancer from the chronic inhalation of Cd.

Cadmium is a potential reproductive and developmental toxicant. California has designated Cd as causing reproductive toxicity under its Proposition 65 regulation.

Animal studies indicate that eating or drinking Cd may cause high blood pressure, iron-poor blood, liver disease, or nerve or brain damage.

Environmental Hazards

Cadmium enters the environment primarily through human activities such as mining and smelting operations, fuel combustion, disposal of metal-containing products, and application of phosphate fertilizer or sewage sludges. Cd that is in or attached to small particles can enter the air, especially during incineration. The main species of Cd found in the atmosphere is Cd oxide, though some Cd salts, such as Cd chloride, also exist. In water, Cd can exist as the hydrated ion, or as ionic complexes with other inorganic or organic substances.

Cadmium in its ionic form is toxic to a variety of eukaryotic cells, including human cells. Once cadmium is absorbed inside the body, it is very slowly eliminated from the body and thus accumulates in humans and animals. A tragic mass poisoning case in Toyama Prefecture, Japan in 1950 illustrates Cd's toxicity. Cadmium had leached from wastes at a nearby lead-zinc mine and contaminated the village water supply, causing itai-itai disease in people exposed to the contamination. Symptoms of this disease include kidney dysfunctions and softening of the bones.

(For section references see endnote #1)

Uses Nationally and in Massachusetts

National Uses

In the U.S the major use of Cd compounds is Cd hydroxide used in the manufacture of nickel-Cd batteries. Other uses include manufacture of pigments (as Cd selenide and Cd sulfide), coatings and plating solutions (as Cd fluoroborate, Cd iodide, Cd oxide, and Cd sulfate), and stabilizers for plastics (as Cd oxide, Cd laurate, and Cd stearate).

Overall, Massachusetts has experienced a 73% reduction in the use of cadmium and cadmium compounds since 1990.

Batteries: Nickel Cd is currently the most widely used Cd battery, and accounts for nearly all of the Cd used in batteries. This amounts to approximately three-fourths of the total Cd used in the United States. Silver Cd is also used in batteries for aircraft and space applications.

Pigments: Cadmium pigments account for approximately 12 percent of the Cd used in the United States. More than 85 percent of Cd pigments are used in plastics applications. Other uses of Cd pigments include paints, ceramic ware, glass, and decorative coatings for metals, printing inks, and rubber.

Polymer Stabilizers: Cadmium salts of long-chain fatty acids, such as Cd carboxylate, Cd laurate, and Cd stearate, have traditionally been used as heat and light stabilizers in polyvinyl chloride (PVC). However, use of Cd stabilizers has decreased in the United States as other viable and less toxic alternatives, such as barium-zinc, calcium-zinc, and organotin stabilizers have become available.

Coatings and Plating Solutions: About 8 percent of the Cd used in the United States goes into metal coatings and plating solutions. Cadmium coatings are applied to steel products such as aircraft landing gear components, automotive brake parts, fasteners of all types, and springs. In addition, Cd coatings have been widely used on electrical and electronic components, such as connectors,

Table 1. Massachusetts Cd and Cd compounds Consumption by Industry Sector (1990 – 2005)

Industry Sector	Facility Name	Location	Use (pounds)	
			1990	2005
Custom Compound Resins	AlphaGary	Leominster	433,952	0
	Clariant Corp Master Batches Division	Holden	46,300	0
Plastics Film and Sheet	Regalite Plastics Corporation	Newton	37,368	0
	Vernon Plastics Company	Haverhill	34,921	0
Wire and Wiring Devices	American Insulated Wire Corp	Attleboro	180,000	0
	Checon Corporation	Attleboro	0	191,180
Metal Products Manufacturing	BASF Catalysts LLC	Plainville	69,800	0
	Metalor Technologies USA	Attleboro	18,180	0
	Engineered Materials Solutions Inc	Attleboro	0	16,855
Electroplating	New Method Plating Corp	Worcester	22,360	21,960
	Texas Instruments	Attleboro	16,000	0
Total Cd and Cd compounds Use			858,881	229,995

equipment housings, and switches. Cadmium usage for coatings and plating solutions in the U.S. has been greatly reduced since the 1960s, and especially in the 1990s, due to restrictions placed on industries by the U.S. EPA for their use of Cd.

New uses for Cd in the synthesis of ultrathin photovoltaic films comprised of Cd selenide (CdSe) and Cd telluride (CdTe) nanocrystals are currently being developed.

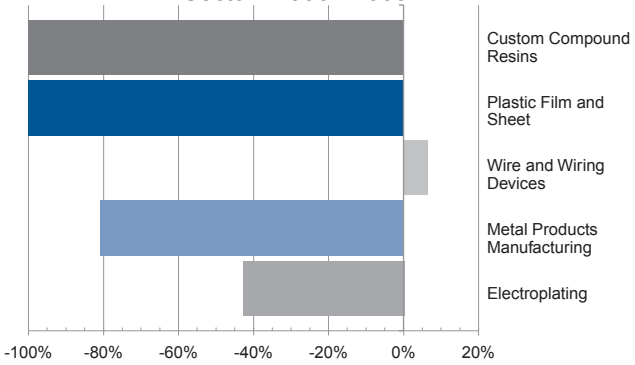
Massachusetts Uses

Between 1990 and 2005 total U.S. Cd consumption declined by 76%. During the same period, Massachusetts' manufacturers followed the national trend experiencing a 73% reduction in the overall use of Cd and Cd compounds since 1990.

Table 1 summarizes the use of Cd and Cd compounds in Massachusetts by industry sector, based on TUR reporting data from Massachusetts companies. For the purpose of assessing trends, industry sectors are aggregated into three use categories - Plastics and Resins Manufacture, Metal Products Manufacturing, Wire and Wiring Device Manufacture and Electroplating.

Cadmium uses and their trends of use in Massachusetts for each of the categories are depicted in Figure 1, and described below.

Figure 1. Percent Change in Use by Industry Sector: 1990 - 2005



Since 1960, the national trends in Cd use have showed rapid growth in NiCd batteries, slow decline in coatings and pigments, and faster declines in all other use categories. NiCd batteries accounted for more than half of the rechargeable battery market in the mid-1990s but since then, the use of NiCd battery technology has begun to decline. In 2006, Cd use in batteries amounted to 82% of apparent consumption, followed by pigments, coatings, plating, stabilizers for plastics, nonferrous alloys, photovoltaic devices, and other. Additional details on current uses of Cd and Cd compounds follow.

Plastics and Resins Manufacture

Uses of Cd and Cd compounds in the plastics and resins sectors are associated with stabilizer additives and pigments in plastic and synthetic products. Plastics formulators in Massachusetts, including manufacturers of custom resin formulations, and manufacturers of plastic products such as sheet and film plastic, eliminated their reportable uses of Cd between 1990 and 2005 (as of 2002 no company reported using greater than 10,000 pounds of Cd or Cd compounds in any one year).

Suitable substitute additives and pigments were identified and used by Clariant Corp Master Batches Division within 4 years of initial reporting. While AlphaGary continued to manufacture custom polymer compounds containing Cd until 2002, it reduced its use of Cd compounds 70% by 2003. It reduced its use of Cd by over 97% within the first year of reporting.

Both manufacturers of plastic film and sheet discontinued their operations prior to 2005. Regalite Plastics Corp curtailed operations in Massachusetts by 1999. Vernon Plastics Company discontinued operations in 2002.

Wire and Wiring Device Manufacture

American Insulated Wire Corp used plastics containing Cd compounds in 1990 only. This company, which manufactures electrical and electronic wire, cable and cord set products, serving a variety of markets, continues to manufacture products, but was able to reduce its use of Cd compounds below the reporting threshold within one year of reporting.

Checon Corporation began operations in Massachusetts in 2004. Checon supplies electrical contact materials for a variety of applications, including industrial control, electrical switch, wiring device, appliance, and automotive. Its use of Cd compounds increased over 17% from 2004 to 2005.

Metal Products Manufacturing

Cadmium is used in low melting point and brazing alloys with bismuth, lead and tin. Cadmium containing alloys are used as bearings, solders and copper hardeners in fire detection devices, high-speed machinery, automotive components and nuclear reactor control rods.

Alloy manufacturing industries in Massachusetts include nonferrous rolling and drawing, primary metal products, and motor vehicle parts and accessories. Products manufactured by companies in Massachusetts within these industry sectors include:

- Silver powder and Cd oxide bars
- Silver Cd alloy forming and casting

Engineered Materials Solutions (EMS) began its cold-rolled metal cladding operations in 2000, after separating from its parent company, Texas Instruments. EMS began operations using Cd compounds to manufacture platinum-clad contact terminals in 2001. This operation has had relatively constant use of Cd compounds since that time.

Of the companies who ceased using reportable amounts of Cd by 2005, one company, BASF Catalysts LLC (formerly Engelhard Corp) reported that it had ceased its manufacturing operations by 1993. The second company (Metalor Technologies USA) employed product reformulation techniques to bring its use of Cd below reporting thresholds.

Electroplating

Production processes conducted in the electroplating sector include Cd electroplating and Cd cyanide electroplating.

Between 1990 and 2005, Cd use in electroplating applications decreased by 43% in Massachusetts. This decrease was due primarily to the elimination of Cd-cyanide electroplating operations at the Texas Instruments facility in Attleboro in 2000.

New Method Plating Corp, a job shop operation that does custom electroplating for various customers, has continued its use of Cd electroplating operations fairly steadily over the course of the reporting period. It is common for job shop operations to feel that moving towards safer alternatives is out of their control and instead a function of their customer demands. However other companies have had success in educating their customers about safer viable alternatives, thereby affecting toxics use reduction through changing customer demands.

Companies Entering the Reporting Universe

The TURA Science Advisory Board (SAB) designated Cd and Cd compounds as a higher hazard substances under TURA in January 2008. This designation reduces the reporting threshold for Cd and its compounds to 1,000 lbs/year. TURI anticipates that the number and quantity of Cd and Cd compounds reported for use in subsequent years will therefore increase.

In the resins, pigments and plastics sectors, it is likely that a small percentage of the many Massachusetts companies continue to use cadmium colorant compounds in amounts over the 1,000 pound threshold. TURI estimates that there may be as many as 30 new cadmium compound filers, primarily in SIC 3089 (Plastic Products) and SIC 3087 (Custom Compounded & Plastic Resins), reporting their use of Cd in 2008.

Inputs and Outputs in Massachusetts

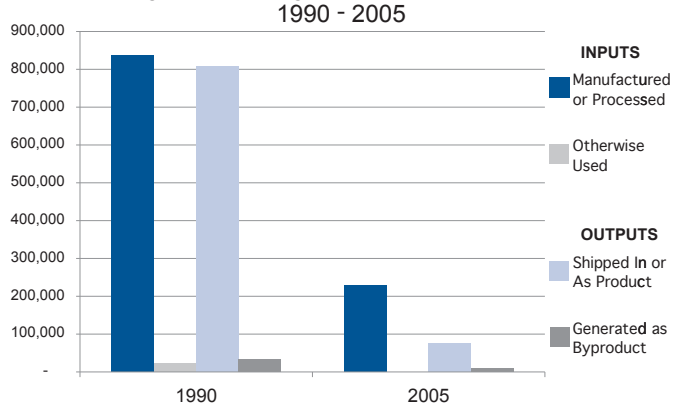
The change from 1990 to 2005 in absolute amount of inputs and outputs in Massachusetts is shown in Figure 2. Inputs include Cd and Cd compounds that are processed or "otherwise used" – ancillary uses that do not become incorporated into the final product. No Cd or Cd compounds are manufactured in Massachusetts above reportable quantities.

Outputs include Cd and Cd compounds that are generated as byproducts (i.e., all non-product material created by a process line prior to release, on-site treatment, or transfer) and the amount of Cd and Cd compounds that are shipped in or as products.

The majority of Cd and Cd compounds used is processed and subsequently shipped in products. Though some data was reported as being "otherwise used", it is likely that this was in error, as the company reporting this way later reported only processed uses.

As shown in Figure 2, the amount of Cd and Cd compounds in the Massachusetts economy (i.e., inputs and outputs based on TURA reporting data) has been significantly reduced overall in the Commonwealth from 1990 to 2005. Specifically, from 1990 to 2005, the amount of Cd and Cd compounds processed was reduced by 73% and the amount of Cd and Cd compounds otherwise used was reduced by 100%. The amount of Cd shipped in products was reduced by 90% and the amount generated as byproducts was reduced by 70% over the same time period.

Figure 2. Change in Inputs and Outputs 1990 - 2005



(For section references see endnote #2)

Alternatives

In part due to increasingly stringent global restrictions, many companies have redesigned their products and processes to use safer alternatives. The significant reduction in use of Cd and Cd compounds by current TURA filers indicates that toxics use reduction options are available for many applications, and that Massachusetts companies are taking advantage of those opportunities.

Substantial information is available on Cd alternatives for soldering, plating, stabilizers, and pigments used in plastics. We also provide information on emerging alternatives to Cd-bearing batteries.

Alternatives for Plastics and Resins

Pigments

Cadmium is used to create a range of yellow colors in plastics formulations. Cadmium sulfides and sulfo-selenides are used in pigments to create a family of yellow/orange/red pigments. Cadmium yellow is created using cadmium sulfide (CdS), cadmium red is cadmium selenide (CdSe) and cadmium orange is an intermediate cadmium sulfoselenide. Cadmium yellow is sometimes mixed with a hydrated chromium oxide pigment to create a bright, pale green mixture. Cadmium has also been used as a weathering, light and heat stabilizer in certain plastic formulations, especially in polyvinyl chloride (PVC).

Processes used in Massachusetts for Cd use as pigments and stabilizer additives include:

- Polymer compounding
- Plastic extrusion on copper wire
- Plastics blending and extruding
- Flexible plastics calendaring

A variety of alternatives are available for Cd in yellow pigments. Some alternatives pose significant health and environmental hazards, while others are superior from a health and environmental perspective.

As early as the beginning of the 1990s, many firms found that they were able to replace Cd in the majority of pigments in which it had been previously used. Alternatives include inorganic pigments based on acid solutions of synthetic oxo-nitrides, iron oxide pigments, bismuth vanadate pigments, organic/inorganic pigment blends using titanium dioxide, mixed metal oxide titanites, and/or iron oxide, rutile tin zinc compounds and others.

Stabilizers

Cadmium has been used as a weathering, light and heat stabilizer primarily in PVC plastic formulations. In the United States, use of Cd-bearing stabilizers has decreased since 1990. Alternatives for Cd stabilizers include barium-zinc, calcium-zinc, antimony, organotin, and organic compound stabilizers. While these alternatives meet the necessary performance criteria for specific applications, antimony and organotin stabilizers are not considered to be safer substitutes because of their respective high toxicities.

Alternatives for Metal Products

Cadmium coatings are applied to various base metals to impart excellent corrosion resistance, especially in marine and alkaline environments. In addition to corrosion protection, Cd coatings provide a low coefficient of friction and therefore good lubricity, good electrical conductivity, easy solderability, and reduced risks of operating mechanisms being jammed by corrosion debris for many components in a wide range of engineering applications throughout industry.

Methods to reduce the use of Cd in metal plating applications include:

- Production process redesign to eliminate the need for the coating.
- Applying metallic-ceramic coatings to replace Cd in more expensive military applications, including landing gear axles of modern aircraft, gas-turbine-engine compressor sections and allied parts.
- Improved methods for the deposition of corrosion-resistant aluminum coatings for aerospace applications using ion- vapor-deposited (IVD) aluminum as an alternative to Cd.
- Using aluminum-molybdenum coatings in applications with specialized requirements, such as aerospace applications.
- Using metallic-ceramic coatings containing zinc, aluminum, or alloys of these metals to replace Cd for plating of fasteners in military and aerospace applications.

Alternatives for Batteries

Because it represents the biggest overall use of cadmium nationwide, it is appropriate to touch upon the availability of alternatives to Ni-Cd batteries.

Currently, the principal alternatives to NiCd batteries are lead-acid, Ni-metal hydride, and lithium-ion batteries as well as fuel cells. Nickel metal hydride batteries possess substantially greater energy-storage capacity and power per unit weight or volume than lead-acid batteries but are very expensive. Since 1991, rechargeable Ni-metal hydride batteries, with low discharge rates and long cycling stability, have been used for consumer applications such as portable computers, cordless appliances and communication equipment. A power-optimized version of Ni-metal hydride batteries are now fitted to commercialized hybrid vehicles. Lithium-ion and sodium–nickel chloride batteries have a lower environmental impact than lead–acid, Ni–Cd and Ni-metal hydride batteries.

(For section references see endnote #3)

Regulatory Context

Due to their serious adverse effects on human health, Cd and its compounds are subject to multiple regulations at the state, federal, and international levels.

EPCRA	Reportable under TRI Subject to Tier II reporting requirements
CAA	Hazardous air pollutant
RCRA	Cadmium is a hazardous waste under RCRA under several circumstances.
Occupational exposures	The OSHA permissible exposure limit (PEL) for airborne exposure to Cd for an eight-hour work shift is 5 µg/m3. OSHA includes Cd on its list of known human carcinogens
SDWA	The maximum contaminant limit set for drinking water is 0.005 mg/L
FDA	The FDA limits the amount of Cd in food colors to 15 parts per million (15 ppm).
Massachusetts: Environmental and Public Health	Ambient air guidelines for Cd - Threshold Effects Exposure Limit of 0.003 µg/m^3 (24-hour average), Allowable Ambient Limit is 0.001 µg/m^3 Drinking water standard (acceptable daily intake over a lifetime exposure) is 0.005 mg/L.

Cadmium and Cd compounds are regulated as carcinogens, and Cd is regulated as a male developmental toxicant, under California's Safe Drinking Water and Toxics Enforcement Act (Proposition 65).

International

The Dangerous Substances Directive (76/769/EEC) prohibits the use of Cd and its compounds in finished plastic products, in

paints, as a stabilizer in PVC products (except where required for safety reasons), and for plating metallic products or components in a variety of sectors. In addition, those Cd compounds that are listed as carcinogens are restricted for use in "substances and preparations placed on the market for sale to the general public."

As part of its REACH regulation, the European Union (EU) restricts the placement of finished articles colored with cadmium if their cadmium content exceeds 0.01 % Cd by mass of the plastic material. This restriction does not affect products when the use of Cd pigments relates to a safety issue.

Cadmium is one of the six chemicals regulated under the Restriction on Hazardous Substances (RoHS), which applies to electrical and electronic equipment sold in the EU. Under RoHS, the maximum allowable concentration of Cd by weight in a homogeneous material is 0.01%.

(For section references see endnote #4)

Endnotes

Go to TURI's website to view full citations: www.turi.org

1. ATSDR, *Toxicological Profile for Cadmium,* 1999; Llewellyn, T.O. *U.S. Bureau of Mines Information Circular 9380: Cadmium (Materials Flow),* 1994; Butterman, W.C. et al., *Open-File Report 02-238, Mineral Commodity Profiles: Cadmium*, 2002; National Toxicology Program, *Substance Profiles: Cadmium (CAS No. 7440-43-9) and Cadmium Compounds*; TOXNET Hazardous Substances Data Bank (HSDB), *Cadmium, Elemental*; EPA *Chemical Sampling Information: Cadmium*; Bertin, G. et al, *Cadmium: cellular effects, modifications of biomolecules, modulation of DNA repair and genotoxic consequences (a review),* Biochimie, 2006; International Occupational Safety and Health Information Centre, *International Chemical Safety Cards: Cadmium*; The National Institute for Occupational Safety and Health, *NIOSH Publication No. 2005-149: NIOSH Pocket Guide to Chemical Hazards: Cadmium dust (as Cd); Cadmium fume (as Cd)*; American Conference of Industrial Hygienists, *ACGIH, 2005 TLVs and BEIs,* 2005; The Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency, *PROPOSITION 65 SAFE HARBOR LEVELS: No Significant Risk Levels for Carcinogens and Maximum Allowable Dose Levels for Chemicals Causing Reproductive Toxicity*; Kellen, E., et al., *Blood cadmium may be associated with bladder carcinogenesis: The Belgian case–control study on bladder cancer.* Cancer Detection and Prevention, 2007; International Agency for Research on Cancer (IARC), *Beryllium, Cadmium, Mercury and Exposures in the Glass Manufacturing Industry. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 58.* 1993: Lyon, France; Wikipedia. *Itai-itai disease*.

2. Butterman, 2002; U.S. Department of the Interior. *U.S. Geological Survey, 2006 Minerals Yearbook: Cadmium* and *U.S. Geological Survey, Mineral Commodity Summaries 2007: Cadmium*; *Massachusetts Toxics Use Reduction Act data*. 2007; Toxics Use Reduction Institute, *Summary of Policy Analysis, Higher Hazard Substance Designation Recommendation: Cadmium (CAS # 7440-43-9) and Cadmium Compounds.*

3. Butterman, 2002; Llewellyn, 1994; Toxics Use Reduction Institute, *Summary of Policy Analysis, Higher Hazard Substance Designation Recommendation: Cadmium (CAS # 7440-43-9) and Cadmium Compounds; Chromatics to Discontinue Production of Heavy Metal-based Colorants.* The Wire Association International, 2006; Mulholland, B.M. *Cadmium Free Colored Engineering Plastics for the Automotive Industry,* in *Annual Technical Conference, Society of Plastics Engineers*, 1994; Wood, A., *Cadmium-free Inorganic Pigments.* Chemical Week, 2000; Jansen, M. et al., *Inorganic Yellow-red Pigments without Toxic Metals.* Nature, 2000; Endriss, H. et al., *Bismuth Vanadate Pigments.* Kunststoffe Plast Europe, 1996; Hatcher, H., et al., *Providing Unique Solutions with a New Pigment Chemistry.* Paint and Coatings Industry, 2004; Davis, *The Product Side of Pollution Prevention: Evaluating the Potential for Safe Substitutes*, 1994; Monaghan, D.P., et al., *An Improved Method for the Deposition of Corrosion-resistant Aluminium Coatings for Aerospace Applications.* Surface and Coatings Technology, 1993; Bielawski, M., *Development of Unbalanced Magnetron Sputtered Al-Mo Coatings for Cadmium Replacement.* Surface Coatings and Technology, 2004; Lambert, et al., *Appropriate Battery Technology for a New, Rechargeable, Micro-solar Lantern.* Journal of Power Sources, 2000; Otto, A. et al., *Development of Fast Kinetics Metal Hydride Alloys and Battery Electrodes for High Power Applications.* Journal of Alloys and Compounds, 1999; Bossche, P.V.d., et al., *SUBAT: An Assessment of Sustainable Battery Technology.* Journal of Power Sources, 2006.

4. *Massachusetts Toxics Use Reduction Act data*. 2007; Toxics Use Reduction Institute, *Summary of Policy Analysis, Higher Hazard Substance Designation Recommendation: Cadmium (CAS # 7440-43-9) and Cadmium Compounds; List of TRI Chemicals;* Occupational Safety and Health Administration (OSHA). *OSHA, 1910, subpart Z, 1910.1027*; ASTDR *ToxFAQs for Cadmium*, 1999; Massachusetts Division of Occupational Safety, M. *"Right-to-Know" Law (MGL 111F), Workplace Regulation (454 CMR 21.00)*; Massachusetts Department of Environmental Protection. *Revised Air Guidelines*; Massachusetts Department of Environmental Protection. *Standards and Guidelines for Contaminants in Massachusetts Drinking Waters,* 2007, *Massachusetts Hazardous Waste regulations, 310 CMR 30.125, Maximum Concentration of Contaminants for Toxicity Characteristic*; *California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65)*; European Community; *Council Directive on the Approximation of the Laws, Regulations and Administrative Provisions of the Member States Relating to Restrictions on the Marketing and Use of Certain Dangerous Substances and Preparations (76/769/EEC)*; European Union. *Regulation EC No 1907/2006, Annex XVII, 18 December 2006.*

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